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Gate Driver Uses AI To Bring Soft Switching Benefits To Inverters

Pre-Switch has expanded its soft-switching IGBT and silicon carbide (SiC) gate driver architecture to cover three-phase power systems. The platform, which includes the Pre-Drive3 controller board, powered by the Pre-Flex FPGA, and RPG gate driver board, enables a doubling of power output for a typical inverter, or an increase in switching speed by a factor of up to 20 times, according to the vendor.

Hard-switching is the most commonly-used technique for dc-ac power converters but it has numerous drawbacks, the largest of which is the introduction of switching losses, which are responsible for a large percentage of power converter losses. In contrast, soft-switching minimizes switching losses but is has never been successfully-implemented for dc-ac systems with varying input voltage, temperature and load conditions. Pre-Switch uses artificial intelligence (AI) to constantly adjust the relative timing of elements within the switching system required to force a resonance to offset the current and voltage (Fig. 1 and table).

Pre-Switch's forced-resonant soft-switching topology replaces the traditional IGBT or silicon carbide driver with a common intelligent controller board, Pre-Drive3, and a specific plug-in RPG (Resonant Power Gate) module optimized for the customer's chosen SiC or IGBT package (see Fig. 2). According to the company, the Pre-Switch architecture delivers the same switching loss performance—or better—as a five-level design, but significantly reduces cost, control complexity and BOM count.

"Customers have called Pre-Switch's soft-switching technology 'the Holy Grail" for power conversion.' eV designers have been amongst the first to adopt this exciting technology because it dramatically-reduces iron core loses in electric motors at cruising torques, providing 5% to 12% more range (Fig. 3). However, our soft-switching technology is also applicable to a wide range of industries, and is independent of device technology," says Bruce T. Renouard, CEO, Pre-Switch. For more information, see the company website.

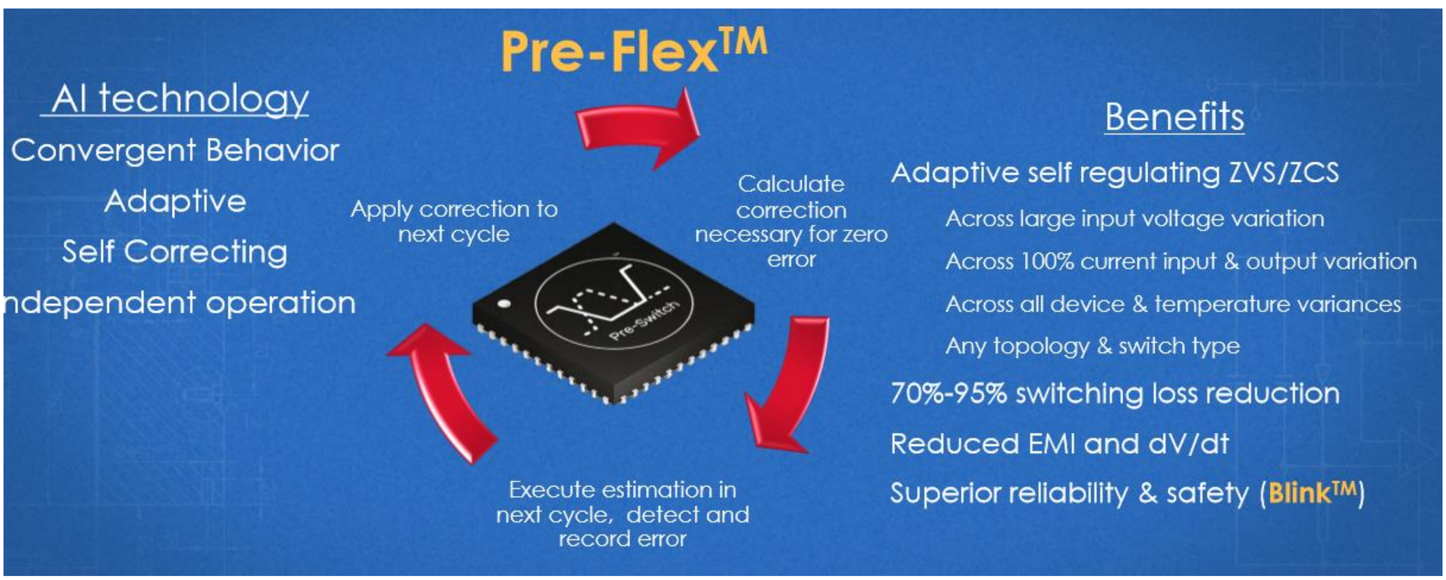
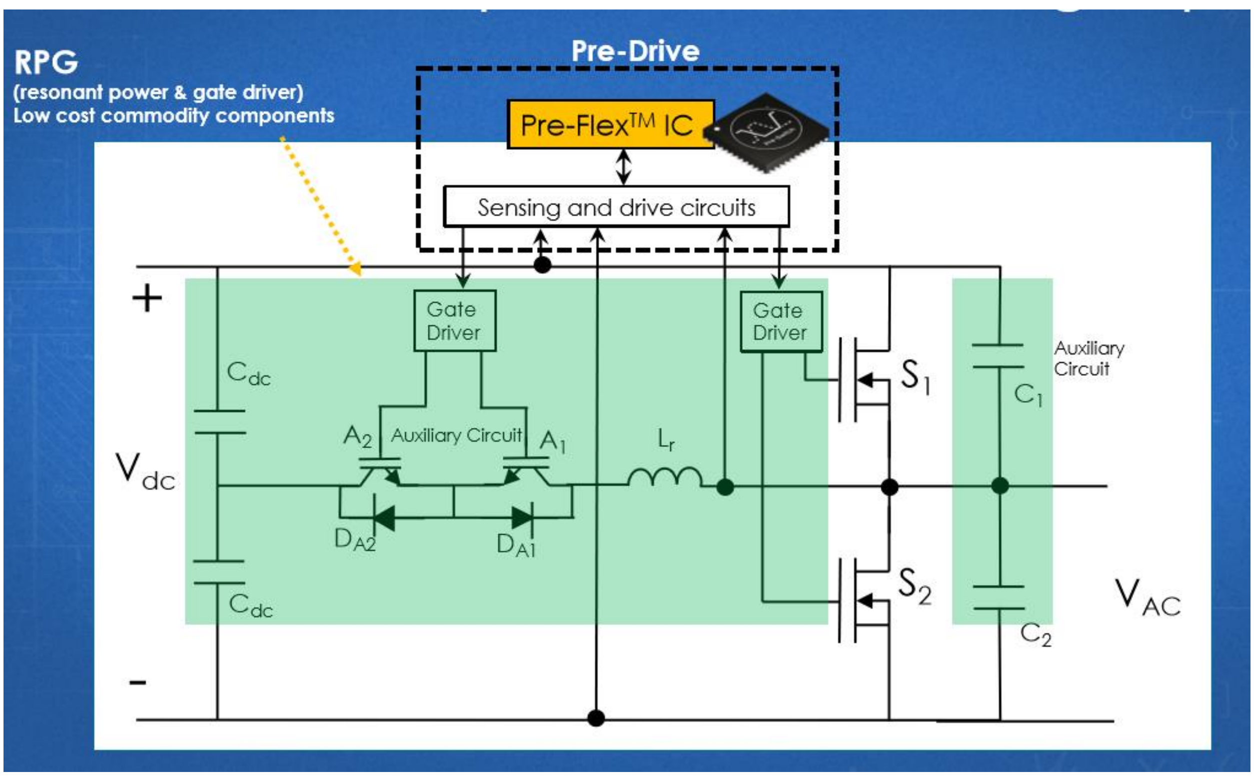


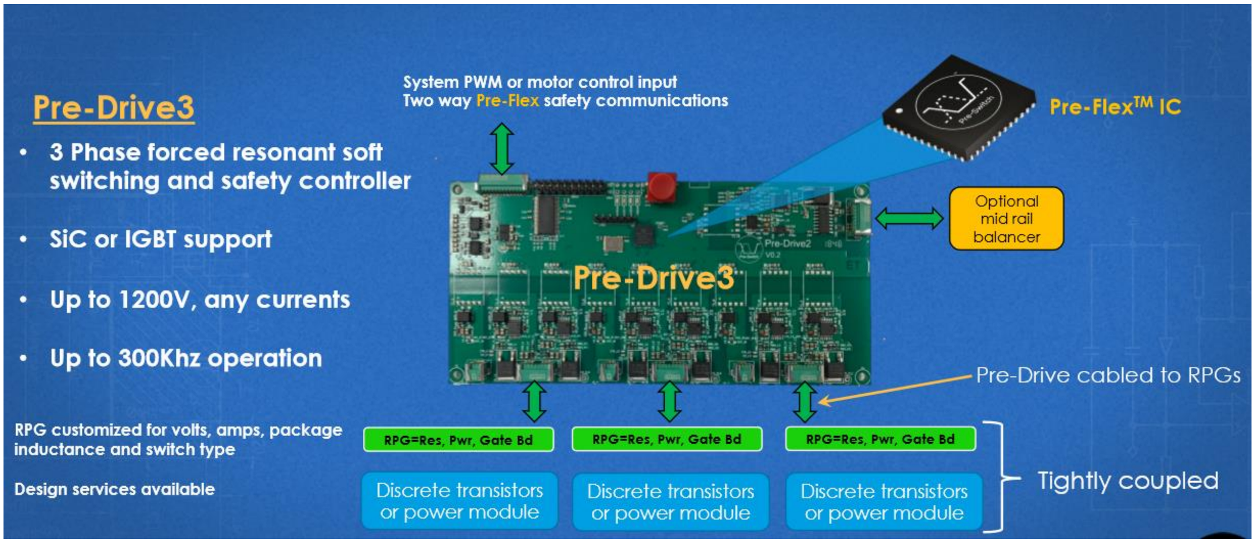
Fig. 1. Pre-Switch uses artificial intelligence to adjust switch timing and achieve ZVS/ZCS operation in an inverter across variations in input voltage, input and output current, device and temperature variations, and topology or switch type.

Table. Comparing switching losses and edge rates of an IGBT driven using Pre-Switch versus its losses and edge rates under hard-switched operation.

Parameter IGBT (800V, 200A @ 125c)	Pre-Switch Rg on 1Ω, Rg off 1Ω	Hard Switch Rg on 3.3Ω, Rg off 1Ω	Hard Switch Rg on 15,7Ω Rg off 1Ω
Turn On Ener10kW invertergy (mJ)	2.0	51.2	101.6
Turn Off Energy (mJ)	14.2	25.6	24.2
Diode RR Energy (mU)	9.8	15.8	12.8
Total (mJ)	26.0	92.6	138.6
Pre-Flex switching loss reduction		72.0%	81.2%
X-Factor		3.6X	5.3X
EMI (on): dV/dt (V/ns)	1.1	1.7	.76
EMI (off): dV/dt (V/ns)	1.1	4.2	4.4
Pre-Switch Blink™	YES	NO	NO

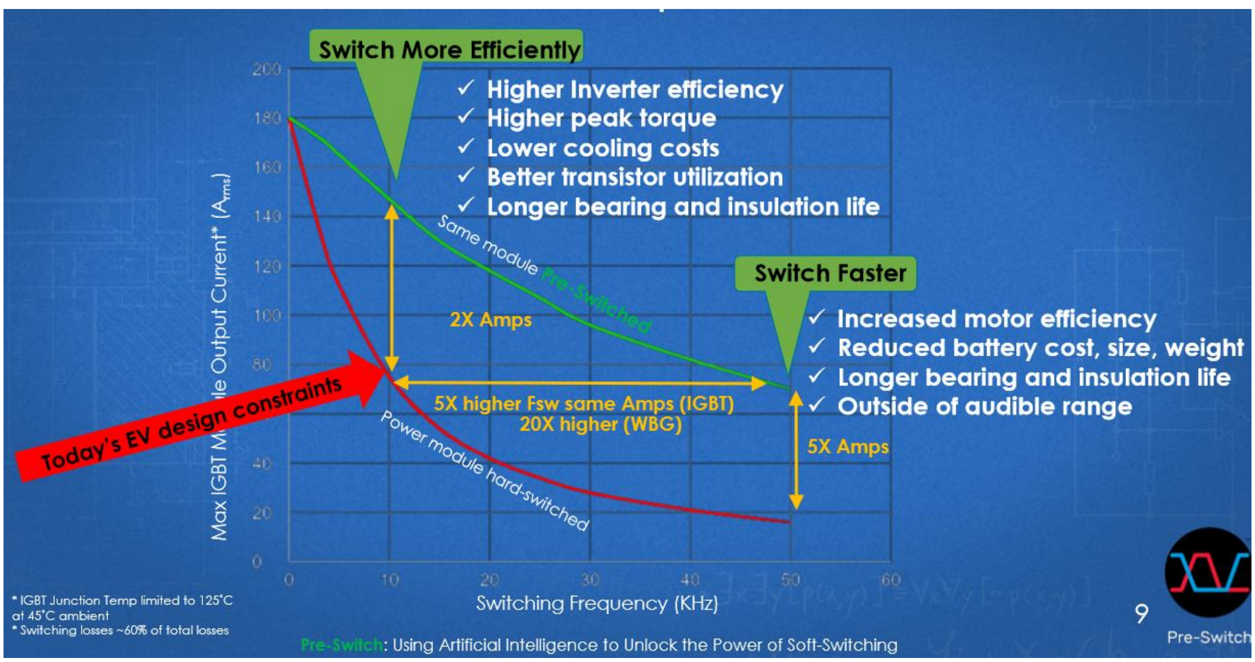


(a)

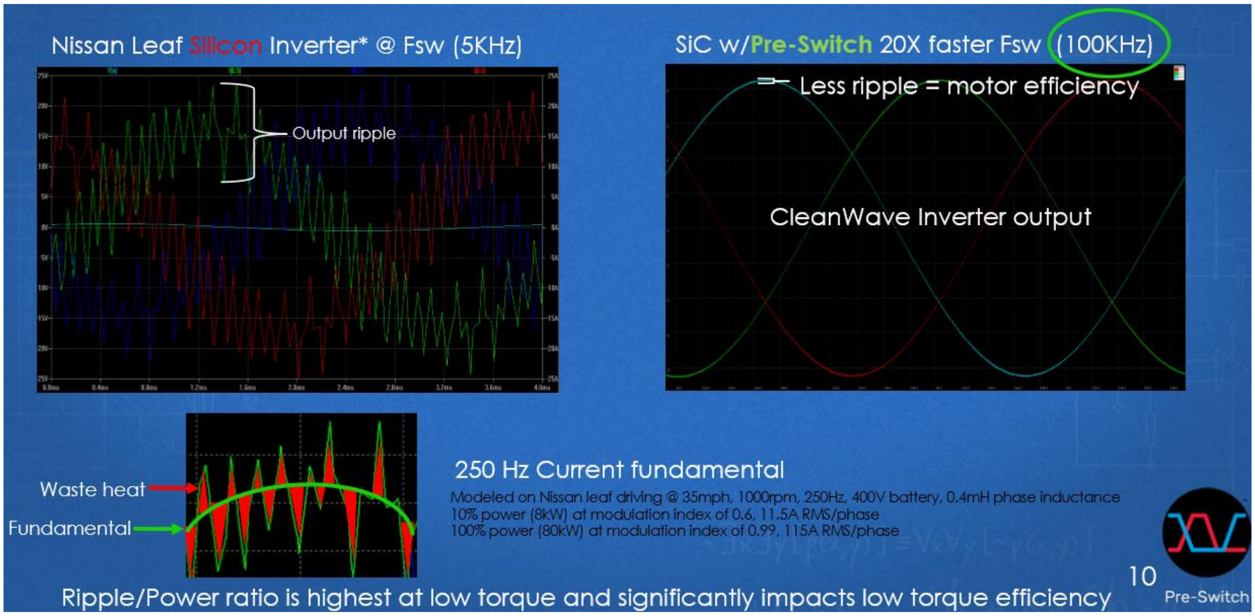


(b)

Fig. 2. Pre-Switch's adaptive soft-switching topology is implemented using a controller IC, the Pre-Drive circuitry shown in the box, in combination with the resonant power and gate drive circuitry highlighted in green (a). In the case of Pre-Drive3, the company packages this technology as a three-phase controller board (b) in which the resonant power and gate driver circuitry is optimized for the particular power switch being used in the application.



(a)



(b)

Fig. 3. Pre-Switch value in EV applications. The three-phase gate drive solution can double power delivered by the inverter or boost switching speeds by up to 20x for the same inverter power output (a). The latter capability can be leveraged to increase eV range by 5% to 12%, which is achieved by increasing the switching frequencies substantially thereby reducing inverter output ripple into the motor. The low ripple reduces iron losses and improves motor efficiency—especially at light loads (b).